

We claim:

1 1. An improvement in a method of epitaxially growing heterostructures on a
2 virtual substrate comprised of an optoelectronic device substrate and handle substrate
3 comprising:
4 initiating bonding of the device substrate to the handle substrate, where the
5 device substrate is composed of a material suitable for fabrication of optoelectronic
6 devices therein and where the handle substrate is composed of an inexpensive material
7 suitable for providing mechanical support;
8 improving the mechanical strength of the device and handle substrates;
9 thinning the device substrate to leave a single-crystal film on the virtual substrate
10 such as by exfoliation of a device film from the device substrate;
11 removing an upper portion of the device film exfoliated from the device substrate,
12 to provide a smoother and less defect prone surface is provided for subsequent
13 optoelectronic device fabrication, and
14 epitaxially growing the heterostructure on the smoothed surface.

1 2. The method of claim 1 where the device substrate is InP/Si and where
2 epitaxially growing the heterostructure on the smoothed surface comprises epitaxially
3 growing a photoluminescent InP/InGaAs/InP double heterostructure on the smoothed
4 surface.

1 3. The method of claim 2 where removing an upper portion of the device film
2 exfoliated from the device substrate comprises chemically polishing the upper portion
3 with a damage selective etch, or mechanically polishing the upper portion.

1 4. The method of claim 1 where the device and handle substrates present a
2 InP/Si interface and where chemically polishing the upper portion with a damage
3 selective etch comprises etching with a mixture of HCl:H₃PO₄:H₂O₂ used in ratios of
4 1:2:2 or 1:2:4.

1 5. The method of claim 2 where the device and handle substrates present a
2 InP/Si interface and where chemically polishing the upper portion with a damage
3 selective etch comprises etching with a mixture of HCl:H₃PO₄:H₂O₂ used in ratios of
4 1:2:2 or 1:2:4.

1 6. The method of claim 1 where the device and handle substrates present an
2 InP/Si interface and where mechanically polishing the upper portion comprises using a
3 colloidal silica slurry in a sodium hypochlorite solution.

1 7. The method of claim 2 where the device and handle substrates present an
2 InP/Si interface and where mechanically polishing the upper portion or both comprises
3 using a colloidal silica slurry in a sodium hypochlorite solution.

1 8. The method of claim 1 further comprising disposing a strain compensation
2 layer on the back surface of the handle substrate.

1 9. The method of claim 8 where the device and handle substrate interface is
2 GaAs/Si, InP/Si or Ge/Si and where disposing a strain compensation layer on the back
3 surface of the handle substrate comprises disposing a film of Ge on the back surface of
4 the Si handle substrate.

1 10. The method of claim 1 where the device substrate is a silicon
2 heterostructure with one material selected from the group consisting of III/V compound
3 semiconductors, II/VI semiconductors, group IV semiconductors, and optical
4 ferroelectric oxides, and where epitaxially growing the heterostructure on the smoothed
5 surface comprises epitaxially growing a photoluminescent double heterostructure on the
6 smoothed surface.

1 11. An improvement in a heterostructure device layer epitaxially grown on a
2 virtual substrate comprising:
3 a device substrate;
4 a handle substrate, the virtual substrate being formed from the device and handle
5 substrates in which the device substrate is bonded to the handle substrate, in which the
6 device substrate is composed of a material suitable for fabrication of optoelectronic
7 devices, in which the handle substrate is composed of a material suitable for providing
8 mechanical support, in which the mechanical strength of the device and handle

9 substrates is improved, in which the device substrate is thinned to leave a single-crystal
10 film on the virtual substrate such as by exfoliation of a device film from the device
11 substrate, and in which an upper portion of the device film exfoliated from the device
12 substrate is removed to provide a smoother and less defect prone surface for an
13 optoelectronic device, and
14 a heterostructure epitaxially grown on the smoothed surface in which an
15 optoelectronic device may be fabricated.

1 12. The improvement of claim 11 where the device substrate is comprised of
2 InP/Si and where the heterostructure epitaxially grown on the smoothed surface
3 comprises a photoluminescent InP/InGaAs/InP double heterostructure epitaxially grown
4 on the smoothed surface.

1 13. The improvement of claim 12 where removing an upper portion of the
2 device film exfoliated from the device substrate is chemically polished with a damage
3 selective etch, or mechanically polished or both.

1 14. The improvement of claim 11 where the device and handle substrates
2 present a InP/Si interface and where the upper portion is chemically polished with a
3 damage selective etch comprised of etchants made of a mixture of HCl:H₃PO₄:H₂O₂
4 used in ratios of 1:2:2 or 1:2:4.

1 15. The improvement of claim 12 where the device and handle substrates
2 present a InP/Si interface and where the upper portion is chemically polished with a
3 damage selective etch etchants made of a mixture of HCl:H₃PO₄:H₂O₂.

4 16. The improvement of claim 15 where the mixture of HCl:H₃PO₄:H₂O₂ is
5 used in ratios of 1:2:2 and 1:2:4

6 17. The improvement of claim 11 where the device and handle substrates
7 present a InP/Si interface and where the upper portion is mechanically polished using a
8 colloidal silica slurry in a sodium hypochlorite solution.

1 18. The improvement of claim 12 where the device and handle substrates
2 present an InP/Si interface and where the upper portion is mechanically polished using
3 a colloidal silica slurry in a sodium hypochlorite solution.

1 19. The improvement of claim 11 further comprising a strain compensation
2 layer disposed on the back surface of the handle substrate.

1 20. The improvement of claim 19 where the device and handle substrate
2 interface is GaAs/Si, InP/Si or Ge/Si and where the strain compensation layer
3 comprises a film of Ge disposed on the back surface of the Si handle substrate.

- 1 21. The improvement of claim 11 where the device substrate is a silicon
2 heterostructure with one material selected from the group consisting of III/V compound
3 semiconductors, II/VI semiconductors, group IV semiconductors, and optical
4 ferroelectric oxides, and where the epitaxially grown heterostructure on the smoothed
5 surface comprises a photoluminescent double heterostructure epitaxially grown on the
6 smoothed surface.